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# Art. XXI.—*Origin of Mud Island, near Paynesville, Victoria.*

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(Communicated by W. Baragwanath.)

(With Plate XXII.)

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## Introduction.

During 1928, a small "island" suddenly appeared in Lake Victoria, Gippsland, close to the shore of Pelican Point, on Sperm Whale Head, and about 8 miles west of Paynesville. The suddenness of the apparition, the fact that emission of inflammable gases accompanied and followed the rise of the island, and that, about simultaneously, decisive traces of crude oil were obtained in Government bores at Lakes Entrance, combined to give colour to the hypothesis that the mud island itself was produced by an "eruption" from the underlying oil beds (1, p. 29). A critical examination of the facts, however, appears to the author to lead to a totally different explanation.

The island rose with remarkable suddenness, and, at its maximum development, attained a length of some 85 feet with a width of 30 feet and a height of 4 feet above the level of the lake.

When it was visited by the author, at the beginning of May, 1929, the subaerial portion of the "island" had almost entirely disappeared: only a few small mud lumps still rose above the surface of the water. The mud was so soft that the observer sank to the knees in it. From numerous small vents, strings of gas bubbles rose intermittently through the water. Spasmodic periods of activity, at irregular intervals, continue to the present day.

## Geology and Physiography of the Area.

The Gippsland Lakes extend from Sale on the west to Lakes Entrance on the east, a distance of some 55 miles. They are separated from the sea by a narrow sand hummock, through which a restricted outlet is maintained, by means of training walls, with some difficulty. They represent, then, a very con-


LAKES ENTRANCE
METUNG
KING LAKE
PAYNESVILLE
EAGLE POINT BAY
JONES BAY
MITCHELL RIVER
BAIRNSDALE
PRINCES HIGHWAY
LAKE VICTORIA
MUD ISLAND
LAKE REEVE
LAKE WELLINGTON
NINETY MILE BEACH
Scale of Miles
0 1 2 3 4 5 6 7 8

FIG. 1.

siderable area of salt lake, in which tidal action is inappreciable.

The whole structure is of the nature of a drowned river valley of fairly mature development, and is comparable with Port Phillip, Western Port, and other drowned valleys on the Australian coast.

In one respect, however, the Gippsland Lakes are unique; Into them drain several of the largest of the coastal rivers of Victoria. These include the Tambo, Mitchell, Thomson and Latrobe; all streams of some magnitude, draining a large, fertile and relatively well populated district.

Consequently, much aggradation has taken place in the lakes, and they are littered with islands, large and small, and contain innumerable shoals.

As a consequence of their structure, and particularly because of their tidelessness, some of the rivers have developed deltas of a type almost unique. These are particularly well marked in the case of the Tambo and Mitchell rivers, which fall into a broad and well protected part of the Lakes. These streams have built out long "natural jetties" of silt, and have pushed their mouths forward into the lake by the construction of natural canals with these jetties as training walls. (Plate XXI., Fig. 1.)

On a small scale they are strikingly similar to the structures formed at the mouths of the Mississippi, itself considered abnormal, amongst the rivers of the world, as regards the structure of its delta. (See below, description by Shaw.)

In the immediate vicinity of the Lakes, the geological formations are almost exclusively Cainozoic in age.

There are very extensive areas of Recent (and probably Pleistocene) deposits directly associated with the activities of the present day rivers and of their immediate ancestors.

Tertiary formations are extensively developed, and are represented by an upper series, the Kalimnan, and a lower series, the Janjukian, which are Pliocene and Miocene, respectively. These have been shown to attain thicknesses of 250 feet of Kalimnan and upwards of 1200 feet of Janjukian in the bores already sunk. The Janjukian beds consist chiefly of polyzoal marls. At the base these give place to a glauconitic facies, which rests directly on a weathered surface of granite and Palaeozoic rocks.

The Tertiary beds are almost horizontal, and, in the vicinity of Lakes Entrance, dip in a west-south-westerly direction at a very uniform rate of some 50 feet to the mile. Very exhaustive search and detailed mapping by officers of the State Geological Survey have failed to reveal any appreciable disturbance of this very uniform structure, so far as the eastern portion of the Lakes is concerned.

It is possible that future investigation may reveal some disturbances at the western end, near Sale, but no satisfactory evidence is known of any folds and faults in the middle section of the Lakes Area.

At four points within a radius of 3 miles of Lakes Entrance calyx bores have been sunk by the Mines Department. In three of these decisive evidence of the petroliferous nature of the basal beds of the Tertiary System has been obtained, in the form of a rather heavy oil saturating the green sandstone cores. Unfortunately, artesian water was struck coincidently with the oil; and no separation has been effected as yet.

At one point, near the head of a small stream known as the Mississippi (no relation to the Father of Rivers referred to somewhat extensively below), there is a small inlier of granite, which supplies the material for the construction and maintenance of the training walls at Lakes Entrance. It seems highly probable that this is an isolated peak on a "buried ridge" of granite of which the main body outcrops some miles to the north near Colquhoun Railway Station.

The hinterland of the Gippsland Lakes comprises some of the roughest and most picturesque mountain scenery in Australia, forming, as it does, the southern edge of the Australian Alps. These mountains consist, for the most part, of highly contorted and considerably metamorphosed Older Palaeozoic rocks of various types and ages, intruded by immense bosses of granite. Large areas about the headwaters of the Mitchell and Thomson Rivers are occupied by less disturbed and less altered epicontinental formations of Upper Palaeozoic age. The structure of this hinterland, however, does not enter into the present discussion.

## Description of the locality near "Mud Island."

Sperm Whale Head is low for the most part, though scrub-covered sand dunes, ranging to heights of over 30 feet above water level, occur at its western end.

On Sperm Whale Head there are depressions, only a few inches above water level, which are occupied by shallow lagoons, dry in certain seasons, and filled with fine grained marl, which has been worked to some slight extent as a fertiliser. These are very similar to lagoons on the Coorong in South Australia, and to the north of Bunbury in Western Australia. The workings are very crude, and no output is obtained at present. To facilitate the shipping of the product, a small jetty was built on the landward side of the headland in 1927. Since that time the accumulation of sand banks along the shore has been so extensive that the end of the jetty is now high and dry. This is a fact of great scientific importance, indicating, as it does, a very recent change in the physiography of the district, which has led to excessive sedimentation along the shores of Sperm Whale Head. This will be referred to later.

A similar sand spit has formed about 20 chains to the north-east of the jetty, and Mud Island has developed immediately offshore from the point of the sand spit and at a distance from it

of about 15 feet. At the time of our visit, this sand spit was roughly triangular in shape, with its base along the old shore of Pelican Point, and its apex pointing towards Mud Island and the lake. Its base was some 50 yards long and its width, at right angles to the shore, about 30 yards. The subaqueous slopes are extremely steep, the material standing at the maximum angle of repose: so steep, in fact, that we stepped ashore, dry footed, from the bows of the launch by which we had arrived.

The material of the sand spit is rather coarse sand, and is entirely unconsolidated. The instability of the structure was well illustrated by the fact that, immediately on landing, it was noticed that there were freshly developed cracks running right across the spit from side to side. These illustrated, with diagrammatic clearness, the phenomena of normal faulting on a "pocket edition" scale. The outer point of the spit had subsided about an inch,


Fig. 2.

and the "fault crack" was still sharp and unweathered. Even as we watched, tiny landslips were taking place, and the very moderate breeze which was blowing was moving quite an appreciable amount of sand from the sharp edge of the crack. The conclusion is irresistible that the fault had just taken place, and that the impact caused by the grounding of the launch was probably sufficient to disturb the very delicate state of equilibrium of the sand spit.

## The Formation of "Mud Island."

These observations lead to the conclusion that the development of Mud Island is due to no deep-seated cause, connected with the presence of oil at a depth of over 1600 feet, but that the mud bank was produced by the overloading of the incompetent mud foundation of the floor of the lake, through the accumulation on it of the sand spit above described.

Why should such a sand spit have formed recently, and not before?

The author considers that the explanation is to be found in the history of the district since settlement has taken place. This occurred about a hundred years ago. In its early stages it was "light pastoral" occupation. A considerable amount of ring-barking of timber took place, but it is only comparatively recently that there has been really extensive clearing in the watersheds of the Tambo, Mitchell, Thomson, and Latrobe Rivers, which discharge into the lakes. This is particularly the case with the poorer and more sandy soils of the district, many of which, as, for instance, those near Fernbank, are only now being cleared and cultivated.

Persistent overstocking, the extension of agriculture, the damage done by bush fires, road and railway construction and other types of human interference have been responsible for a recent and rapid change in the physiographic conditions of the district, and this change is eminently favourable to a marked augmentation of the rapidity of sedimentation; and, still more, to the transportation of much coarser grained sediment than formerly.

The author has noticed evidence of the same kind at many places round the coast of Australia, where sand dunes, which had long been anchored by the growth of large trees, have *quite recently* been overwhelmed by sand drift from the beaches. It seems probable that, here again, the change of conditions is attributable to man's interference with nature's equilibrium, resulting from the inception and continuance of dredging, breakwater building, harbour works, and probably, more than all, from mining and agricultural operations in the watersheds of the coastal rivers.

The date of formation of the sand spit is certainly open to argument. Local observers will undoubtedly claim that "there has been no difference since my grandfather's time." Such subjective personal impressions, unsupported by accurate objective measurements, are entitled to some weight, but not much. The growth of a sand spit, even though extremely rapid in a geological sense, is so imperceptible as to escape remark, even by trained observers.

There is some evidence, on the ground, supporting the impression that the increase in dimensions of the particular sand spit under consideration has occurred very recently. Of the growth of the sand bank near the jetty there is no shadow of doubt. At "Mud Island," the shore of Sperm Whale Head is marked, in most places, by a low bank of fine clayey sand about a foot above water mark. This, apparently older deposit, is covered with grass, and contains, near the shore line, larger and smaller ponds and lagoons. A little further back there is a low growth of ti-tree and other marsh-loving trees. These features can be readily traced just behind the sand spit, which has the appearance of having been added to the normal shore line, and of being out of harmony with the general characteristics of the latter.

A feature of Mud Island, which has been claimed as conclusive by supporters of the oil eruption theory, is the fact that the mudbank is composed largely of clay. It is stated that such clay does not occur in any quantity on the floor of the lake in the immediate vicinity. This statement has been neither verified nor disproved, so far as the author is aware, by any authentic observations.

In any case, the occurrence of such excessive amounts of clay, far from being damaging to the hypothesis put forward here, is actually one of its strongest supports, as will appear in the sequel, when similar structures in other parts of the world are described for comparison.

The proximate stages in the process of formation of "Mud Island" appear to be as follows:—

(1) After the drowning of the original mature valley of the Tambo-Mitchell-Thomson-Latrobe group of rivers, crustal equilibrium was sufficiently long maintained to permit of the silting up of the drowned valley, with the formation of a protecting bar along the seaward side, forming the Gippsland Lakes.

(2) Minor oscillations of level occurred, but need not be considered in this connection. The streams emptying into this tideless lake built out long deltas recalling, on a small scale, the mighty tentacles thrown out by the Mississippi into the Gulf of Mexico: a comparison of considerable moment. Shaw (see below) comments on the fact that the Mississippi Delta is abnormal in this respect, as compared with the other great deltas of the world.

In addition to these "natural jetties," large numbers of islands were built up in the lakes, and deposits of silt and clay, highly charged with vegetable detritus, were laid down under water. Such was the condition of affairs when the country was settled less than a century ago.

(3) Deforestation, by axe and fire, stocking, agriculture, and a little mining upset the equilibrium which had been established between the processes of erosion and deposition. More material and coarser material was swept down by the streams, altering the nature of the upper levels of the lake deposits, and piling up relatively extensive, coarse-textured and unconsolidated sand banks and spits locally.

(4) Reaching the limits of supporting capacity in places, the foundations of these sand spits give way, not by bodily collapse, but by lateral squeezing out of the more plastic clayey layers between and, in some cases, through the overlying less plastic strata. The laterally displaced material bulged up the overlying beds and caused the development of a shoal, or, in suitable circumstances, of an island. Naturally, in such a "bulge" the plastic, relatively fluid material is present in excessive amount, as compared with that in the more normally stratified lake deposits.

Further, methane and other gases produced by secular alteration of the vegetable contents of the muds, and stored in them to some extent, are liable to find an avenue of escape when the crest of a "bulge" becomes fractured through compression or tension. The escape of such imprisoned gas, especially under the dynamic conditions of flowage of large volumes of mud under pressure, is quite competent to account for the paroxysmal phases in the development of Mud Island which have been referred to by some observers.

That the whole of the gas supply was not exhausted by the paroxysmal stages is shown by the continued discharge of gas in small quantities.

It is to be noted, also, that the situation of Mud Island in relation to the sand spit is just what would be expected, and just what is encountered in similar occurrences elsewhere. The displaced mud cannot escape in all directions, because of the resistance offered by the mass of the relatively solid mainland; the whole of the force is spent *from* the shore and *towards* the open water, so that the "island" appears just offshore.

It is quite possible that, if sand bars were to accumulate in open water, the uplift would be more or less symmetrical, and therefore less intense in its local manifestations. For all that is known to the contrary many such readjustments of the lake bottom might take place without attracting attention, since there is no regular periodical resurvey of the lake floor in progress.

## Analogous Phenomena in other Places.

### Mud Lumps in the Mississippi Delta.

Since the phenomenon possesses more than academic interest, and since a most extraordinarily close parallel exists in the case of the "mud lumps" of the Mississippi Delta, investigated by Shaw (2, pp. 11-27), a somewhat detailed description of these structures may be given.

According to Shaw, "mud lumps," in the form of large swellings of blue mud, rise at intervals within a mile or two of each of the mouths of the Mississippi. In some instances the rise is sudden, though generally it extends over months or years. The lumps rise just offshore, and have a surface extent of an acre or more and a height of 5 to 10 feet. Other lumps do not reach the surface of the water, but form shoals. Usually the lumps attain a height of about 20 to 30 feet above the bottom in the vicinity. They rarely extend more than 8 feet or less than 2 feet above the water.

Their appearance and disappearance are very irregular. Many of them subside and some have disappeared in a night. Their formation is most active during flood periods, when aggradation is most extensive. Observations by pilots and sailors of the formation of the mud lumps are fairly consistent. Shaw doubts the authenticity of reports of roaring noises and flashes of light which have been made in one or two instances. The present writer finds no difficulty in accepting such reports, though the conclusions he draws therefrom are not those intended by the observers. It is probable that, occasionally, the formation of a "lump" is more paroxysmal than usual, because of somewhat abnormal gas accumulation. In such a case the roar would not be unexpected. It seems within the bounds of possibility, also, that during such a paroxysmal gas eruption, fragments of wet, shining mud might be thrown spinning into the air. Light, momentarily reflected from such wet, moving surfaces, might easily be mistaken by an unskilled observer for flashes of fire; particularly when the preconceived idea that the phenomenon as a whole is volcanic is taken into consideration.

Shaw states (2, pp. 24, 25), "The structure of the mud lumps appears to be comparable with that of bysmaliths. . . . A dark bluish grey clay of medium stickiness forms the central core. . . . Upon and around the core lies a series of faulted and folded strata of sand and silt which have been carried up from the sea bottom and deformed in the upheaval. The upper parts of the mud lumps bear numerous fissures and some normal faults. . . ."

"One of the most significant facts concerning the mud lumps is that they contain much more clay than has been found in other parts of the Delta deposits. . . . This strongly suggests that the mud lumps have been produced by the lateral flowage

of soft layers of clay, for no such thick layers of clay have been found elsewhere in the Delta."

The mud lumps nearly all give rise to mud springs which discharge salty sludge and gas. These springs are usually associated with fissures, though, in some instances, the fissures are well-nigh obliterated. The materials of the Mississippi Delta contain large amounts of both marsh gas and water. Gas escapes in many places, particularly in the vicinity of the mud lumps. This gas is found on analysis to consist of marsh gas, $CH_4$, mixed with nitrogen, oxygen and carbon dioxide. Such a composition indicates that the gas is not of deep-seated origin, but has developed within a few feet of the surface.

Shaw concludes, "The facts that the mud lumps are by far the thickest bodies of clay found in the Delta and that the clay is overlain and underlain by materials similar to those found elsewhere throughout the lower end of the Delta suggest that they are produced by the squeezing of the soft layers and the accumulation of clay from such layers in places where the pressure is less strong, and that the lumps are not upheaved by any such force as volcanism or by the pressure from the accumulation of salt, sulphur, or gas below the surface."

"The mud lumps appear to be the product of flow, because in no other places have such thick bodies of clay been formed, and the facts that they occur almost exclusively near the ends of the passes . . . where probably the principal part of the sediment is being deposited, and that they are most active during and after times of high (flood) water seems to be in accord with the hypothesis here presented."

"The flowage of semifluid clay has frequently been observed. It sometimes causes great difficulty in railway building, or gives rise to surprising changes in swamps."

### *Comments on the Views of Shaw.*

Allowing for the vast difference in scale between the two cases, Shaw's description of the phenomena at the Mouth of the Mississippi, to which the author's attention has been drawn only very recently, applies almost word for word to the formation of "Mud Island" in Lake Victoria. The similar abnormalities of the two Deltas have been commented on above, and supply an additional reason for the correlation of the phenomena.

The activity of the Mississippi mud lumps "during and immediately after high water" is due, of course, to the fact that such periods mark the maximum imposition of sediment as loading on the bottom. Shaw quotes an estimate by an officer of the United States Corps of Engineers, in which it is stated that 2,500,000 cubic yards of material were deposited during the high water stage of the Mississippi from March to May, inclusive, 1913. This additional material produced an increased pressure

of 1,800,000 tons, or a mean additional pressure of 400 pounds per square foot. The maximum pressure was 825 pounds per square foot.

The author has brought forward reasons why a different cause may be sought to explain the time coincidence in the case of the formation of "Mud Island."

Various accounts of the formation of "Mud Island" suggest that there were one or more paroxysmal phases. It would appear from general considerations, and from the author's observations of the amount of vegetable debris present in the muds of the lake bottom, that there is a somewhat abnormally large amount of marsh gas generated in the locality.

Shaw advances many weighty reasons, too long for quotation *in extenso,* against the acceptance of the gas-origin theory. While these arguments are almost certainly valid in reference to the Mississippi mud lumps and the Victorian "Mud Island," it does not preclude the possibility of such action taking place under conditions favouring the generation and storage, under pressure, of unusually large amounts of gases derived from decomposing vegetation. Shaw himself quotes a case described by Potonié (3) where such an origin is suggested. The author has not had access to this work of Potonié's.

### Analogies in Australia.

Instances of flowage of muds under the pressure of artificial embankments have been observed personally by the author.

In the construction of the railway embankments along the foreshores of Mullet Creek, Hawkesbury River, N.S.W., during 1887, phenomena very strikingly similar to the formation of Mud Island occurred. Mullet Creek is a deep, drowned river valley, completely filled with silty sediment. Small tributary gullies, similarly filled with silt, had to be crossed by means of embankments.

Much trouble and expense were caused by the foundering of these embankments, with the formation of mud islands of exactly the same type and in exactly the same relative position as that occupied by the Mud Island in Gippsland. It seems likely that most of the subsidences were gradual, but the author can remember that there were circumstantial accounts, at the time, of the complete disappearance of embankments overnight.

On another occasion, a railway embankment between Waratah and Sandgate, on the Hunter River Delta in N.S.W., was being enlarged, and a similar subsidence took place, rather suddenly, but not with paroxysmal violence. Swellings were thrown up in the swamps on both sides, and the forest trees were thrown markedly out of perpendicular.

The author has described a somewhat similar phenomenon in the Collie Coal Basin of Western Australia (4). In this case, the accumulation of thick masses of sand, which were being deposited to form the roof of the main seam in the area now being worked by the Westralian Colliery, caused a failure of the soft muds

forming the floor of the seam. The (still soft) coal was fractured and displaced, and large volumes of mud were injected through it into the roof sandstones. This formed a break in the continuity of the seam which had most serious consequences on the profitable working of the mine.

## Objections to the Theory that the Formation of Mud Island is in any way connected genetically with the Tertiary Oil Sands of Lakes Entrance.

The reasons advanced for considering that both the mud lumps of the Mississippi and "Mud Island" in Lake Victoria are of purely superficial origin are so weighty that the author is unable to accept the alternative suggestion of connection, in the latter case, with underlying oil formations.

It seems necessary to recapitulate several facts which are regarded as conclusive evidence against such connection.

(1) The oil which has been encountered at Lakes Entrance occurs in glauconitic sandstone forming the basal beds of the Tertiary System in this area. These beds lie on an old, decomposed and eroded surface of granite and Older Palaeozoic strata; and the strong presumption is that the migration of the oil is along the unconformity.

(2) At Lakes Entrance, the base of the oil stratum is encountered at depths of 1275 feet in No. 2 Bore and 1404 feet in No. 3 Bore, Lakes Entrance, Parish of Colquhoun. This is in strict conformity with the surface indications of regional dip in the district, which amounts to only some 50 feet per mile in a general westerly direction.

(3) There is no authentic evidence of any disturbance of this gentle structure in the area under consideration. In absence of such evidence it is reasonable to assume that the official view of the Geological Survey, that the structure is a very uniform one, is correct.

(4) The basal Tertiary beds should be met with at a depth of about 2450 feet in the neighbourhood of the "Mud Island." That they will be found to contain small quantities of oil similar to those encountered at Lakes Entrance seems highly probable.

(5) The oil, so far discovered, is closely associated with artesian water. Up to the present it has not been found possible to effect a separation so that the oil can be extracted commercially. There is no evidence that the artesian water has been able to produce the violent paroxysmal outburst claimed to have been responsible for the formation of the mud island.

(6) Gas, in moderate quantities, is associated with the oil manifestations at Lakes Entrance. Its pressure is sufficient to keep it in evidence, in spite of the hydrostatic head of water rising to the surface. The pressure is, however, only just suffi-

cient for this, and there is no excess capable of producing violent eruptive effects in addition to balancing the water pressure.

(7) If the uplift at "Mud Island" marks the escape of imprisoned gas under high pressure from the oilsand along a fault plane, it is most extraordinary that the formation of the island should be its only manifestation, and that the appearance of the island should have been delayed until the present moment. If a leaky geological structure were present we should expect a line of similar manifestations in various stages from incipience to extinction. Examples of this kind are frequent in the case of the "mound springs" of Central Australia, which mark the outlets of the water from the Great Artesian Basin. The author claims to have made a suggestion which is adequate to explain, not only the phenomenon of formation of "Mud Island," but also the coincidence of its appearance at the present juncture.

(8) There is a high degree of probability of the formation of similar structures in the lakes in the future, in positions analogous with that occupied by mud island in relation to growing sand spits.

(9) The formation of somewhat similar mud islands and of "mud volcanoes" in direct and genetic association with existing oilfields is, of course, a well-known phenomenon. In such cases, however, the whole environment precludes the possibility of development by sedimentary overloading and favours that by oil and gas eruption. A case in point is the formation, recently, of a mud island immediately off the coast of Trinidad (5). While there are superficial points of resemblance between the phenomena in this case and in the formation of "Mud Island," no scientific reader could fail to distinguish the fundamental differences in every important particular.

## Summary.

"Mud Island," which appeared in Lake Victoria about eight miles west of Paynesville, during 1928, owes its origin to an upheaval of the lake floor. This was produced by the lateral squeezing out of a sub-surface layer of plastic clay from beneath an area overloaded by the recent accumulation of sand, forming a spit extending out from the shore of Pelican Point on Sperm Whale Head.

The reason for the uniqueness of the phenomenon, and for its occurrence at this particular time, is believed to be that the effects of man's interference with the equilibrium between the processes of erosion and sedimentation, established over ages preceding white settlement of the area, are only just beginning to make themselves apparent.

Deforestation, stocking, agriculture, mining, road and railway construction, and other rapid disturbances of natural conditions, have combined to cause a comparatively rapid, and cumulatively

important, increase in the bulk of sedimentation in the Lakes, which has manifested itself in the bulging up of the lake floor locally.

Reasons are given for believing that the apparition has nothing whatever to do with the presence or absence of petroleum beneath the surface of this part of Victoria.

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## Explanation of Plate XXII.

Fig. 1.—Natural jetties of silt at mouth of Mitchell River, Gippsland Lakes.

Fig. 2.—Mud Island off Pelican Point, Sperm Whale Head, Gippsland Lakes, showing portion of shore of Pelican Point in left foreground.

Fig. 3.—Closer view of Mud Island, with launch anchored alongside.